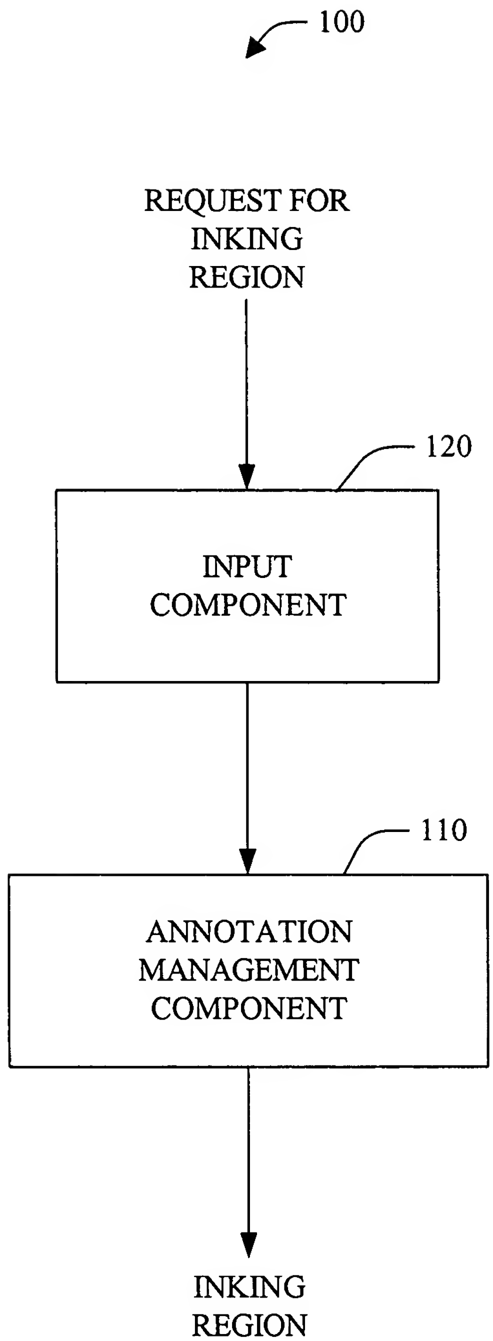
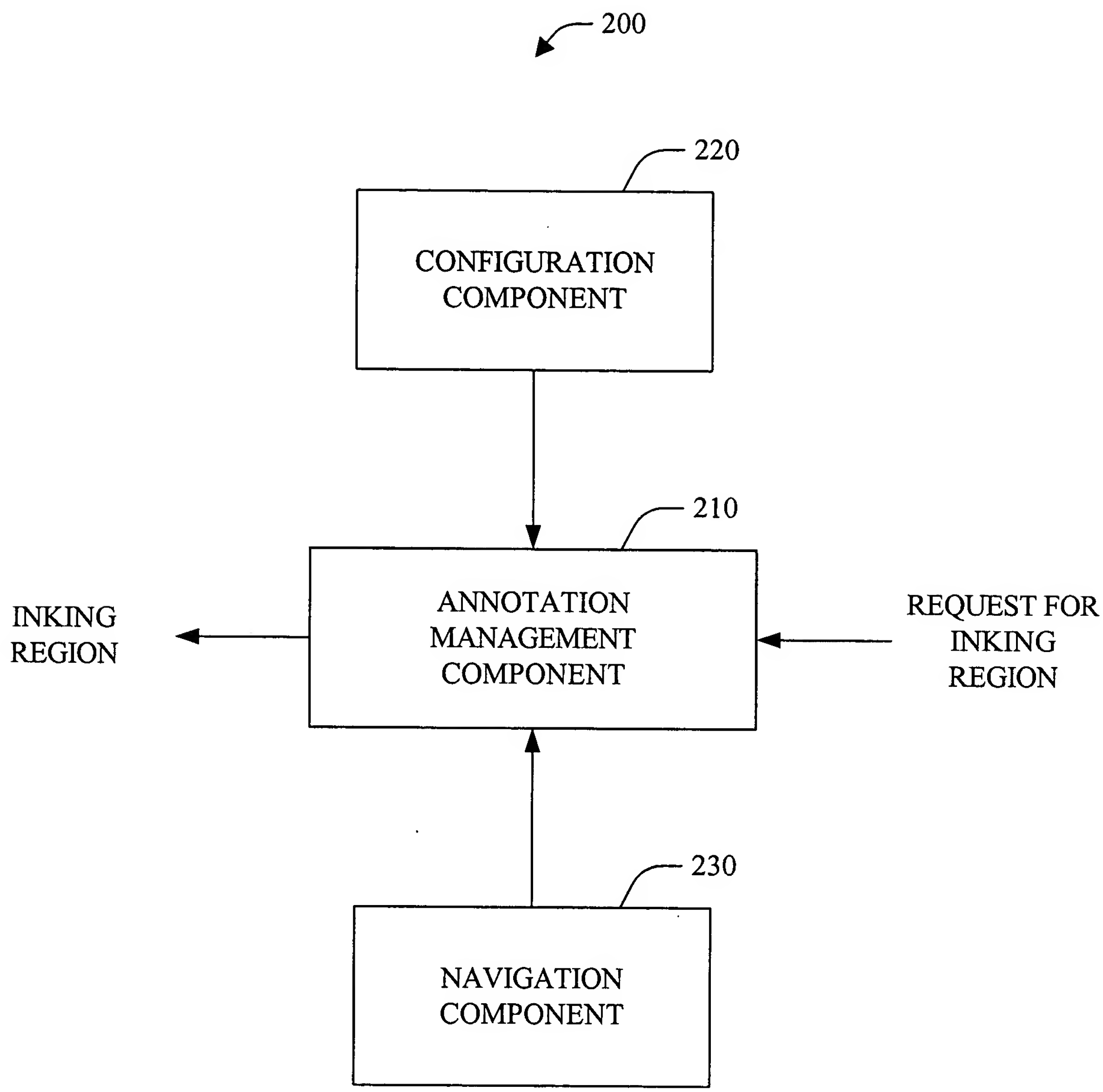


100
REQUEST FOR INKING REGION
120
INPUT COMPONENT
110
ANNOTATION MANAGEMENT COMPONENT
INKING REGION

FIG. 1



200
220
CONFIGURATION COMPONENT
210
INKING REGION
ANNOTATION MANAGEMENT COMPONENT
REQUEST FOR INKING REGION
230
NAVIGATION COMPONENT

FIG. 2

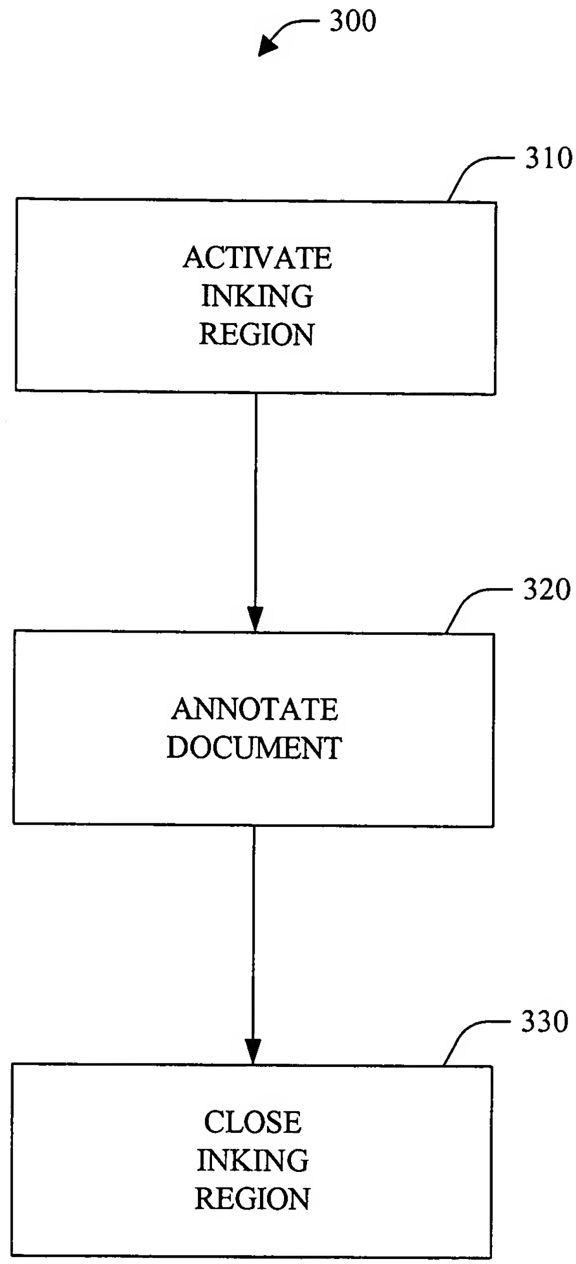

300
310
ACTIVATE INKING REGION
320
ANNOTATE DOCUMENT
330
CLOSE INKING REGION

FIG. 3

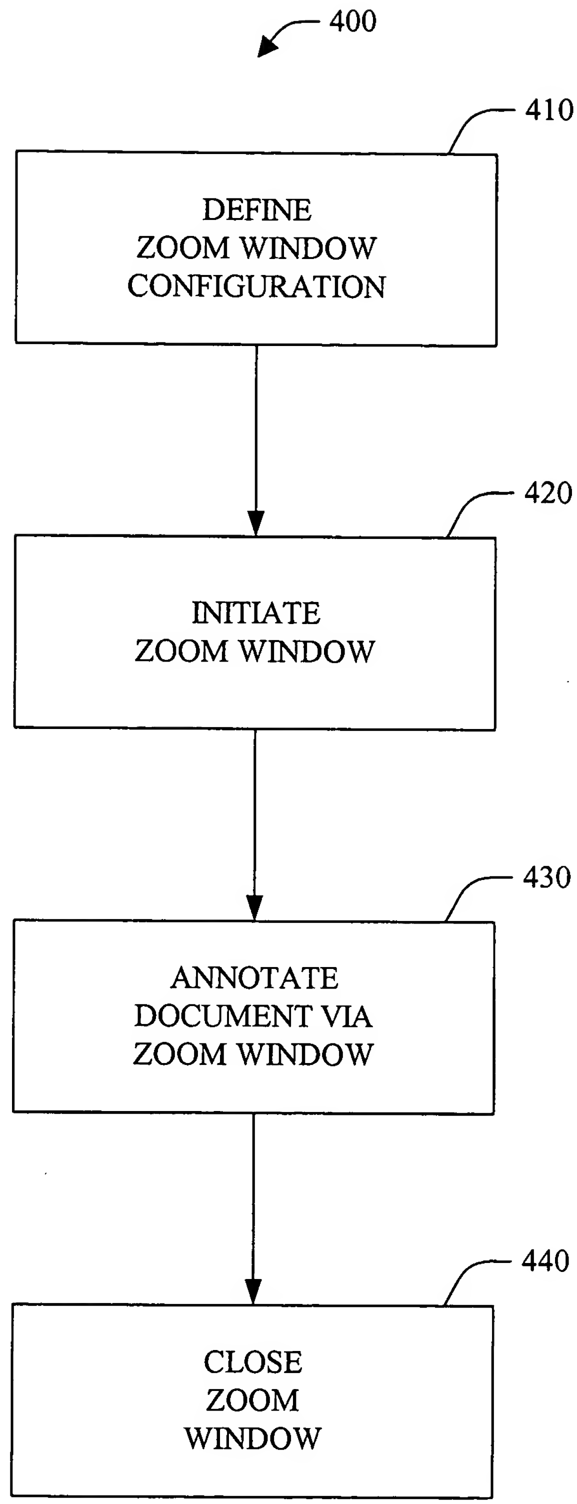

400
410
DEFINE ZOOM WINDOW CONFIGURATION
420
INITIATE ZOOM WINDOW
430
ANNOTATE DOCUMENT VIA ZOOM WINDOW
440
CLOSE ZOOM WINDOW

FIG. 4

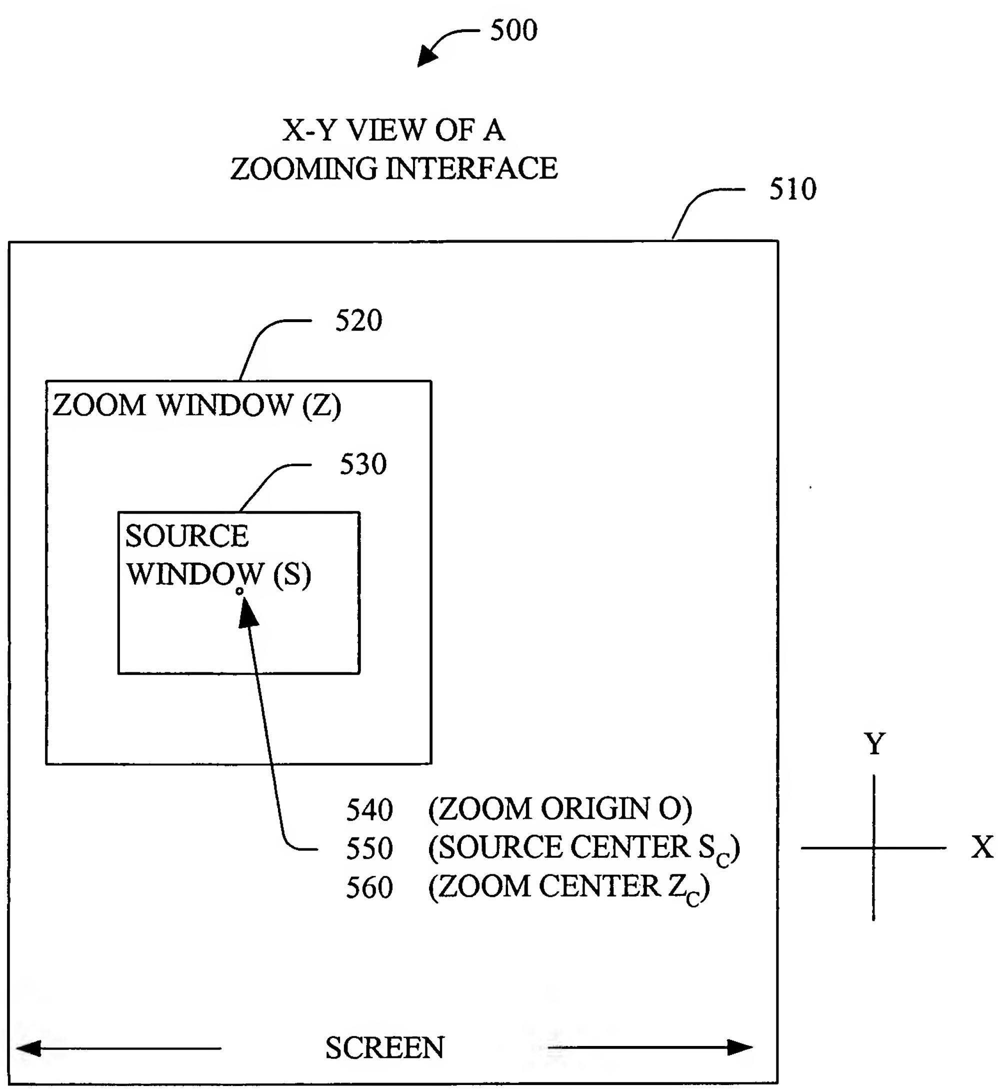

500
X-Y VIEW OF A
ZOOMING INTERFACE
510
520
ZOOM WINDOW (Z)
530
SOURCE
WINDOW (S)
540 (ZOOM ORIGIN O)
550 (SOURCE CENTER S_C)
560 (ZOOM CENTER Z_C)
SCREEN
Y
X

FIG. 5

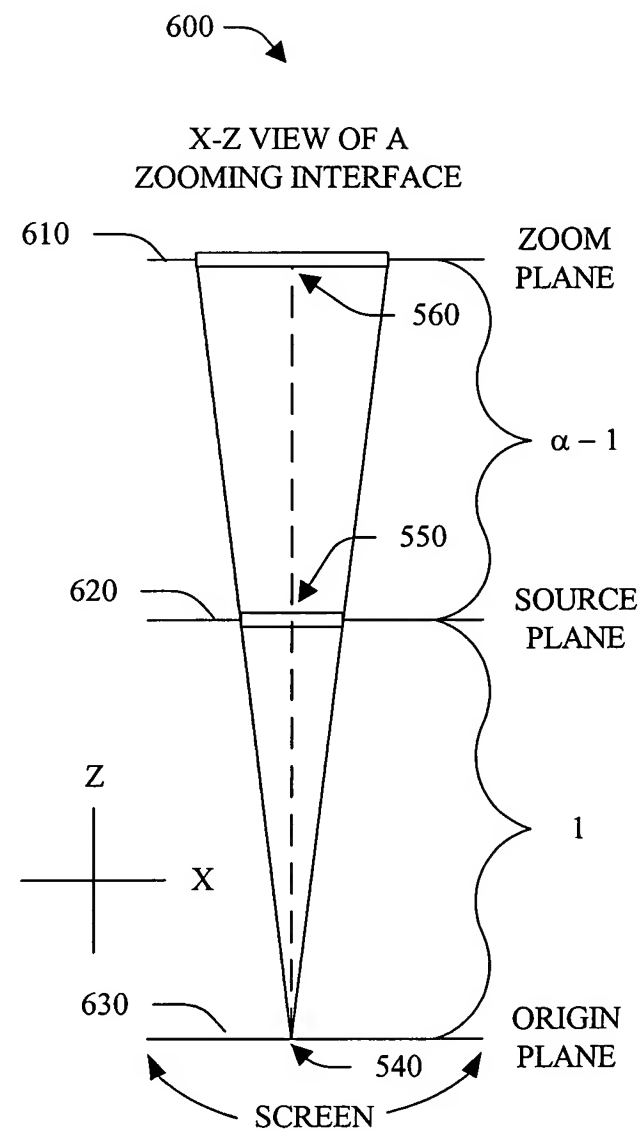

600
X-Z VIEW OF A
ZOOMING INTERFACE
610
ZOOM
PLANE
560
$\alpha - 1$
550
620
SOURCE
PLANE
Z
X
1
630
ORIGIN
PLANE
540
SCREEN

FIG. 6

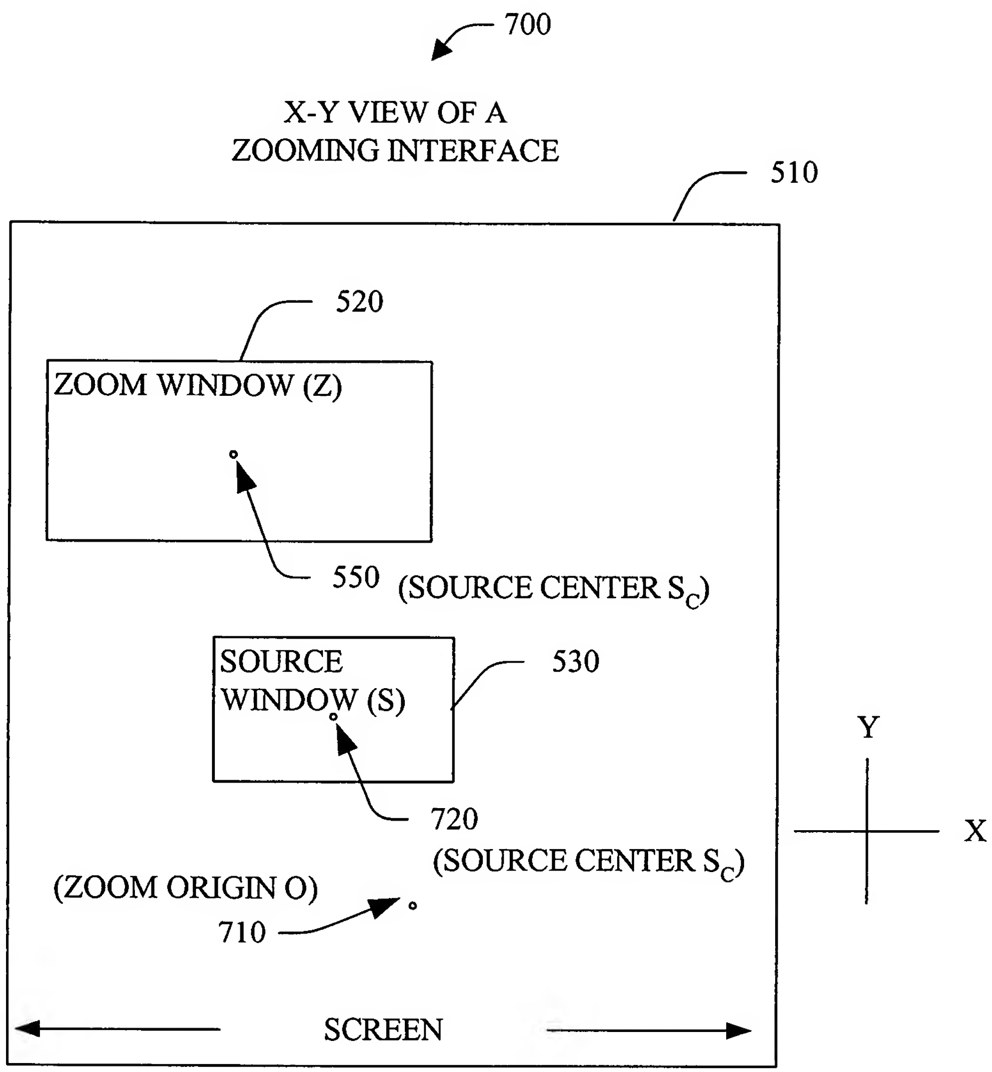

700
X-Y VIEW OF A
ZOOMING INTERFACE
510
520
ZOOM WINDOW (Z)
550
(SOURCE CENTER S_C)
SOURCE
WINDOW (S)
530
720
(SOURCE CENTER S_C)
(ZOOM ORIGIN O)
710
SCREEN
Y
X

FIG. 7

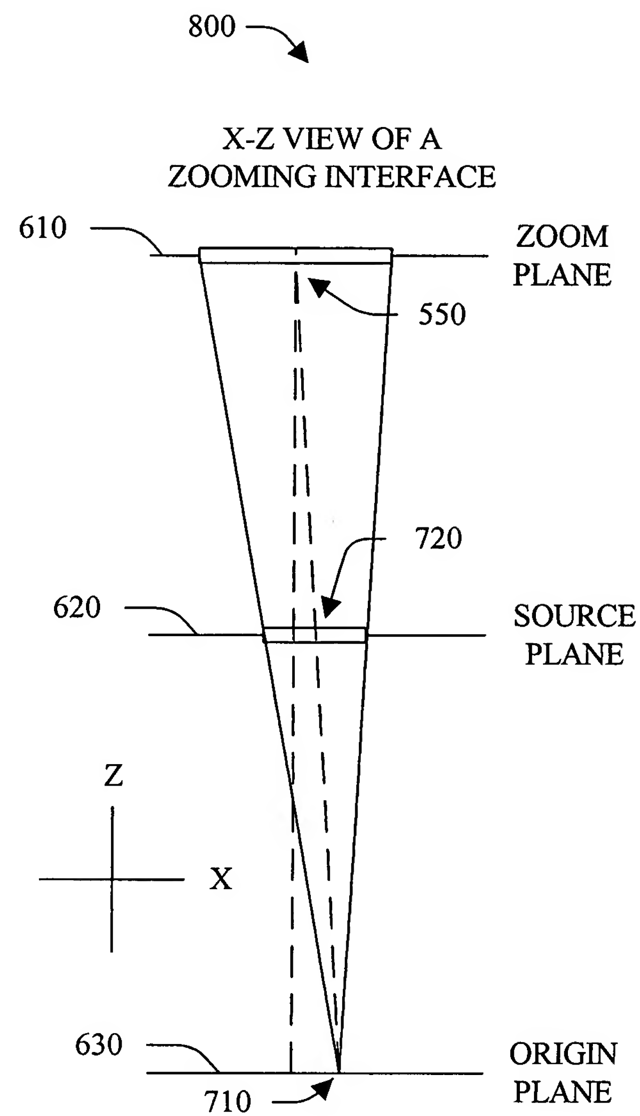
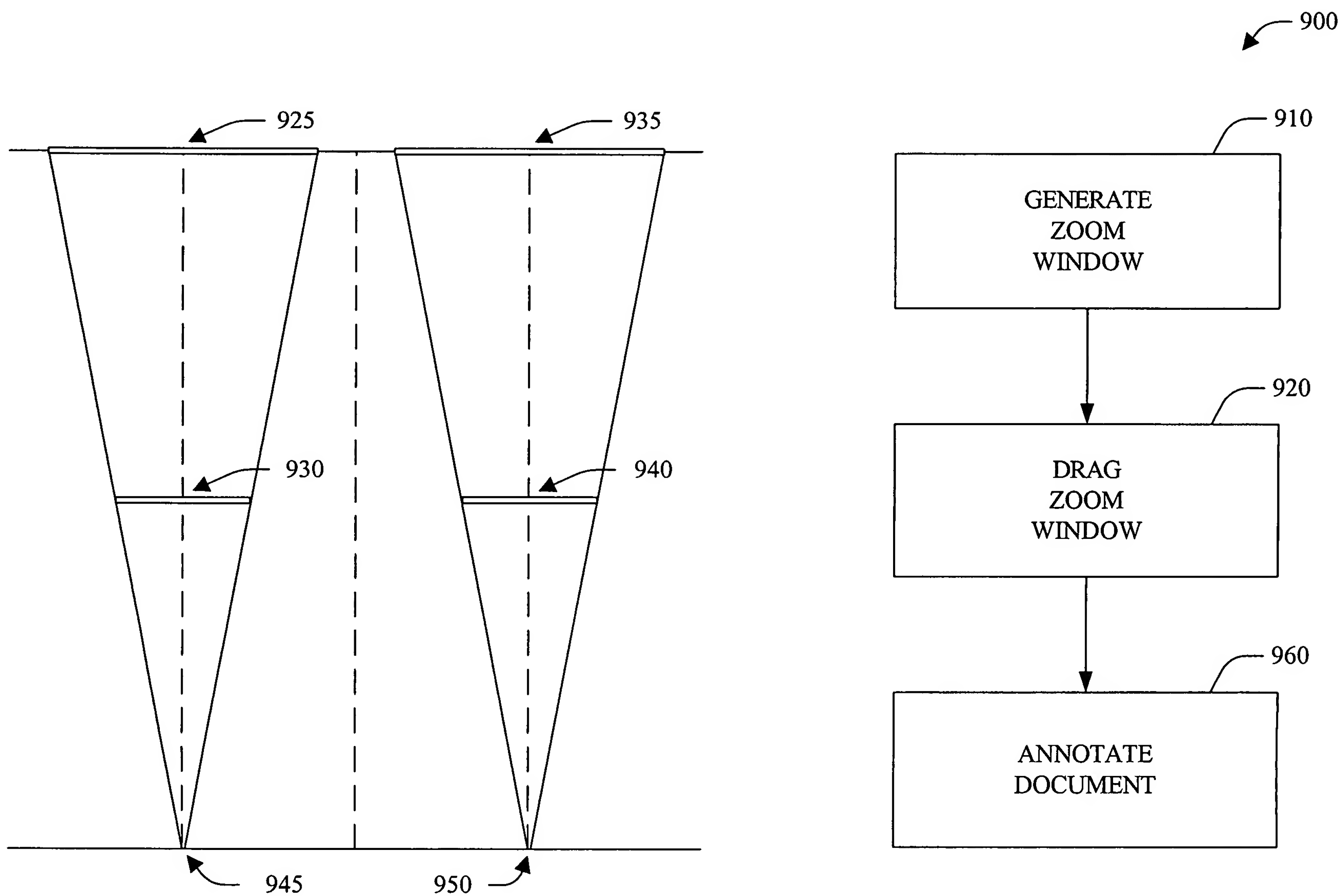

800
X-Z VIEW OF A
ZOOMING INTERFACE
610
ZOOM
PLANE
550
720
620
SOURCE
PLANE
Z
X
630
ORIGIN
PLANE
710

FIG. 8



900
925
935
930
940
945
950
910
GENERATE ZOOM WINDOW
920
DRAG ZOOM WINDOW
960
ANNOTATE DOCUMENT

FIG. 9

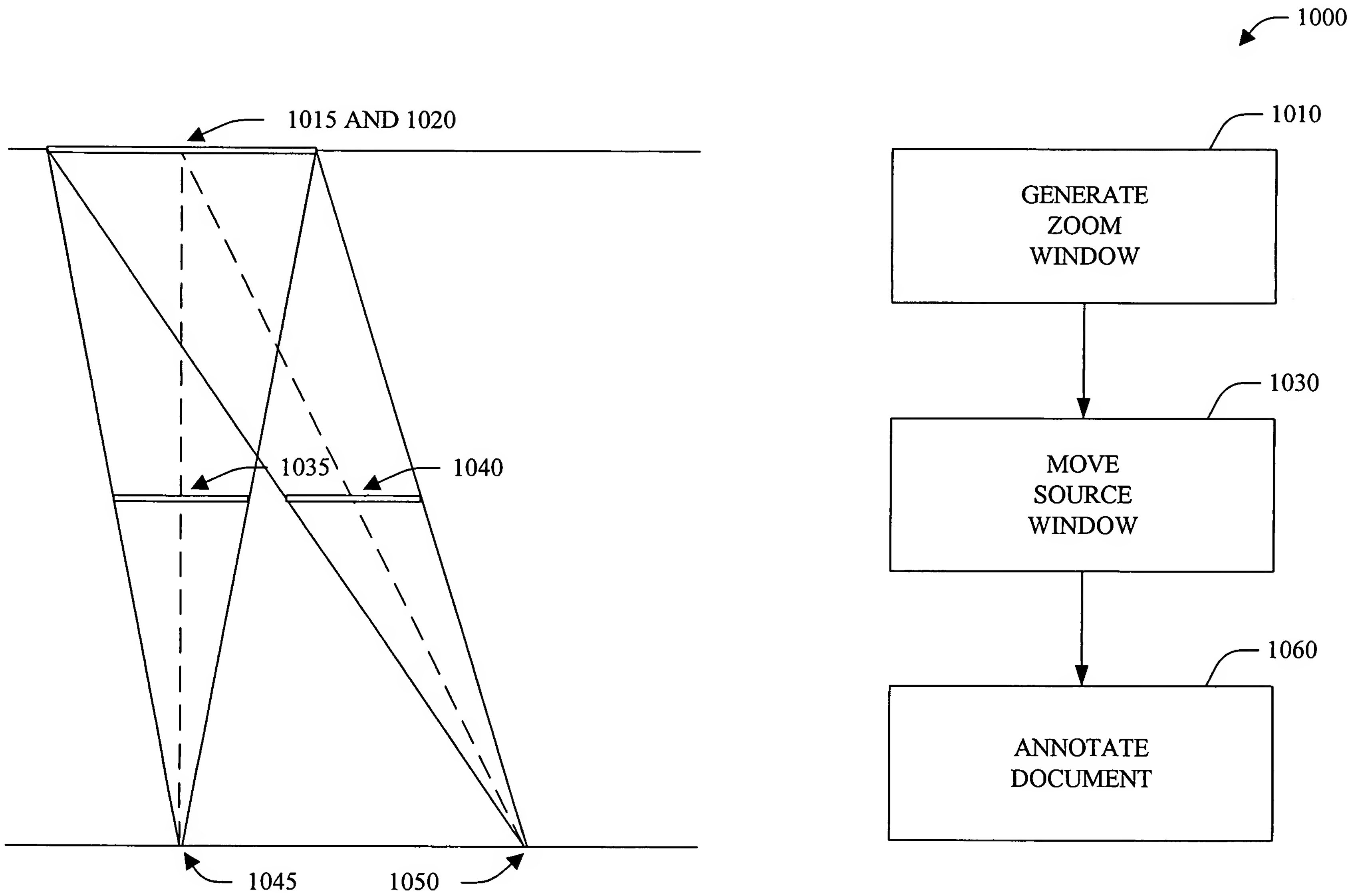

1000
1015 AND 1020
1035
1040
1045
1050
1010
GENERATE
ZOOM
WINDOW
1030
MOVE
SOURCE
WINDOW
1060
ANNOTATE
DOCUMENT

FIG. 10

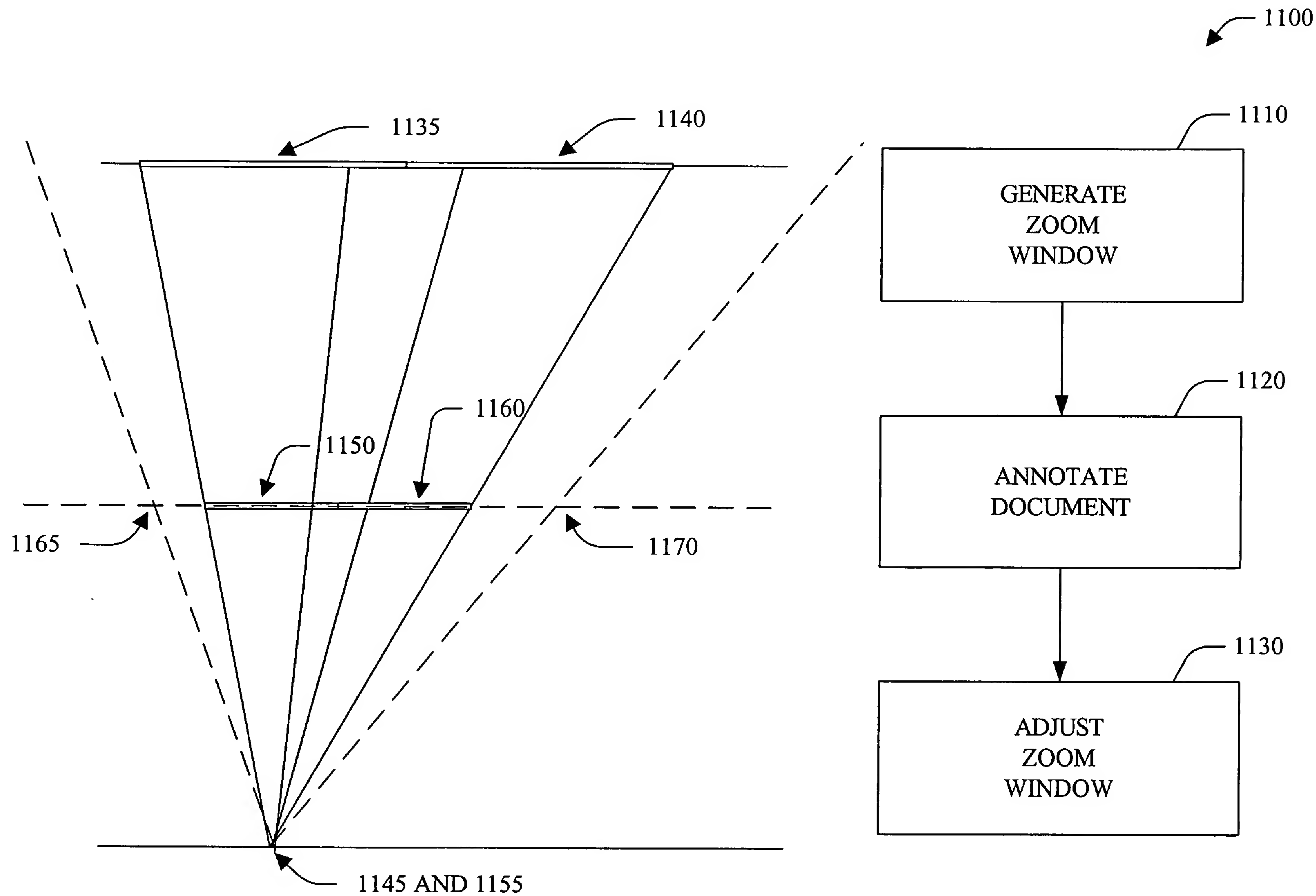

1100
1135
1140
1110
GENERATE ZOOM WINDOW
1120
ANNOTATE DOCUMENT
1130
ADJUST ZOOM WINDOW
1160
1150
1165
1170
1145 AND 1155

FIG. 11

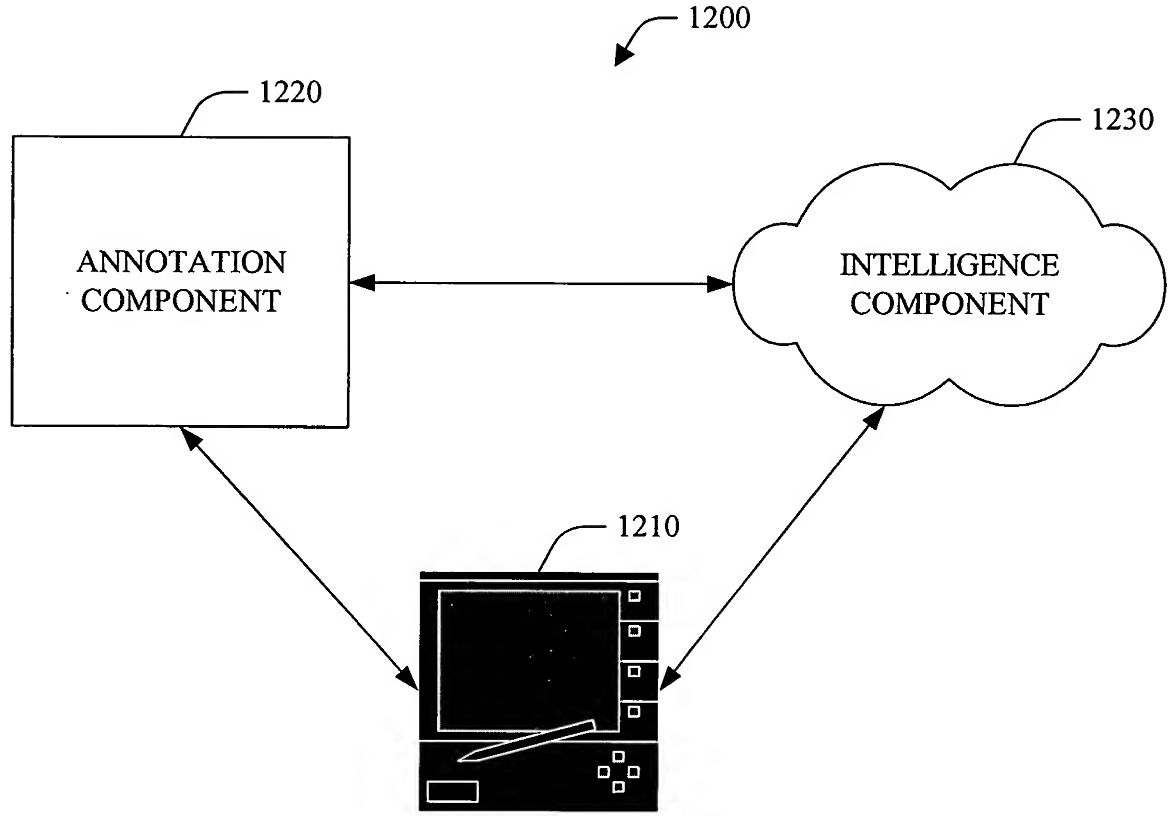
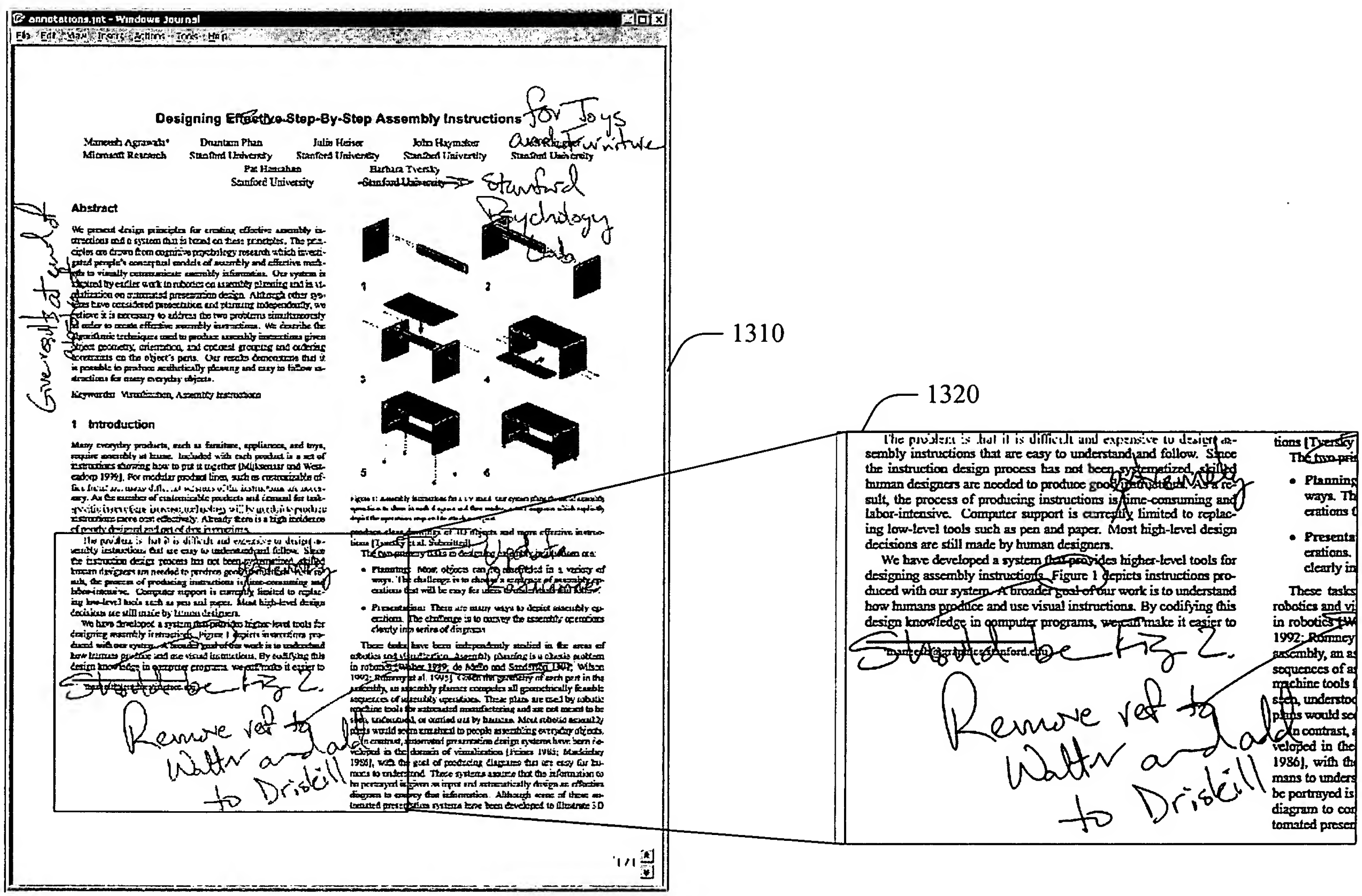

1200
1220
ANNOTATION
COMPONENT
1230
INTELLIGENCE
COMPONENT
1210

FIG. 12



1310
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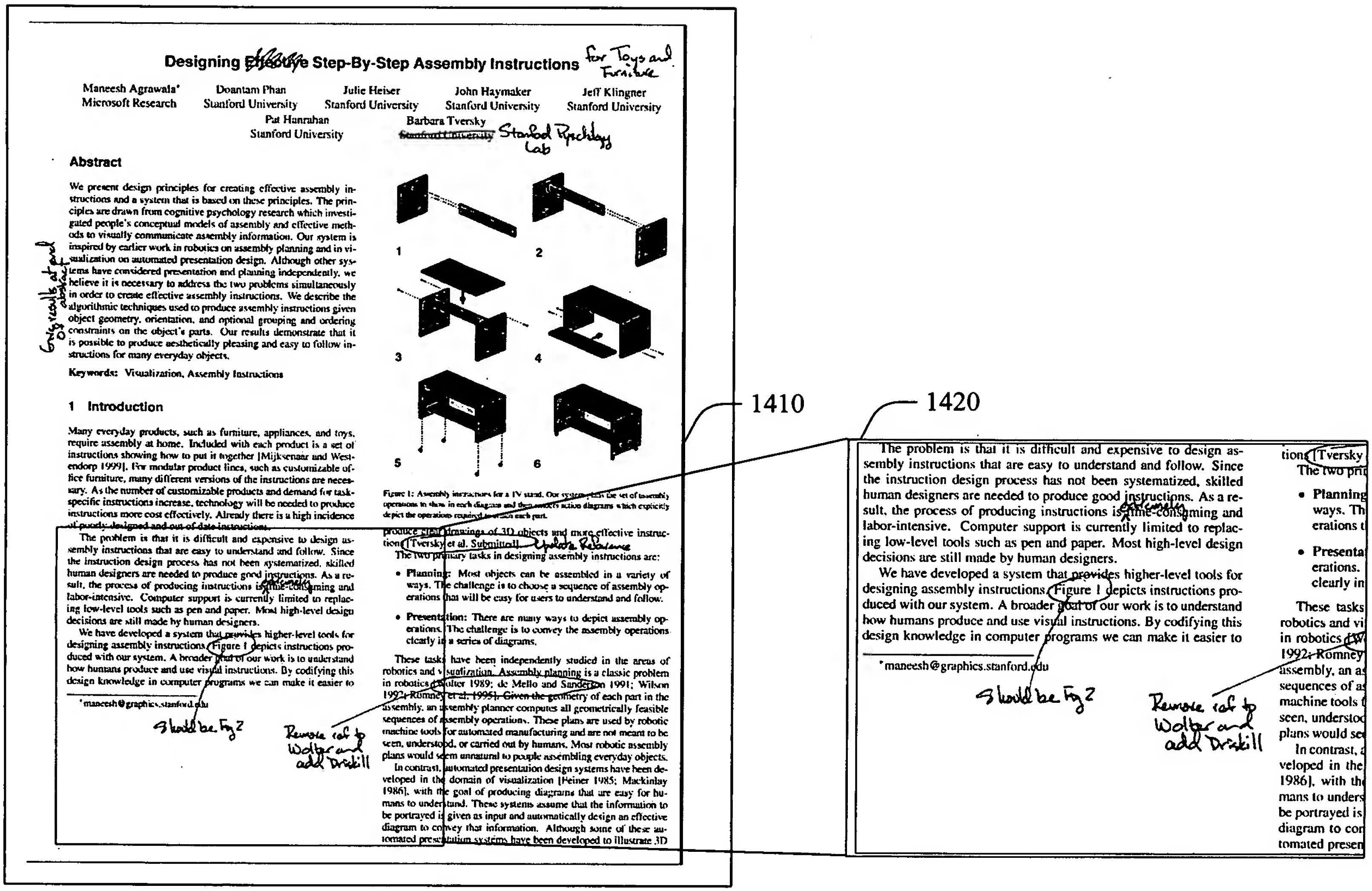
Designing Effective Step-By-Step Assembly Instructions
for Toys and Furniture
Stanford Psychology Lab
Give results at end of abstract
Abstract
1 Introduction
Should be Fig 2.
Remove ref to Walter and add to Driskill

FIG. 13



Designing ~~Effective~~ Step-By-Step Assembly Instructions for Toys and Furniture
Maneesh Agrawala* Microsoft Research
Doantam Phan Stanford University
Julie Heiser Stanford University
John Haymaker Stanford University
Jeff Klingner Stanford University
Pat Hanrahan Stanford University
Barbara Tversky ~~Stanford University~~ Stanford Psychology Lab
Abstract
We present design principles for creating effective assembly instructions and a system that is based on these principles. The principles are drawn from cognitive psychology research which investigated people's conceptual models of assembly and effective methods to visually communicate assembly information. Our system is inspired by earlier work in robotics on assembly planning and in visualization on automated presentation design. Although other systems have considered presentation and planning independently, we believe it is necessary to address the two problems simultaneously in order to create effective assembly instructions. We describe the algorithmic techniques used to produce assembly instructions given object geometry, orientation, and optional grouping and ordering constraints on the object's parts. Our results demonstrate that it is possible to produce aesthetically pleasing and easy to follow instructions for many everyday objects.
Only results at end of abstract
Keywords: Visualization, Assembly Instructions
1 Introduction
1 2 3 4 5 6
Figure 1: Assembly instructions for a TV stand.
Update Reference
1410
1420
The problem is that it is difficult and expensive to design assembly instructions that are easy to understand and follow. Since the instruction design process has not been systematized, skilled human designers are needed to produce good instructions. As a result, the process of producing instructions is time-consuming and labor-intensive. Computer support is currently limited to replacing low-level tools such as pen and paper. Most high-level design decisions are still made by human designers.
We have developed a system that provides higher-level tools for designing assembly instructions. Figure 1 depicts instructions produced with our system. A broader goal of our work is to understand how humans produce and use visual instructions. By codifying this design knowledge in computer programs we can make it easier to
*maneesh@graphics.stanford.edu
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• Planning
ways. Th
erations t
• Presenta
erations.
clearly in
These tasks
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in robotics [W
1992; Romney
assembly, an a
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machine tools f
seen, understo
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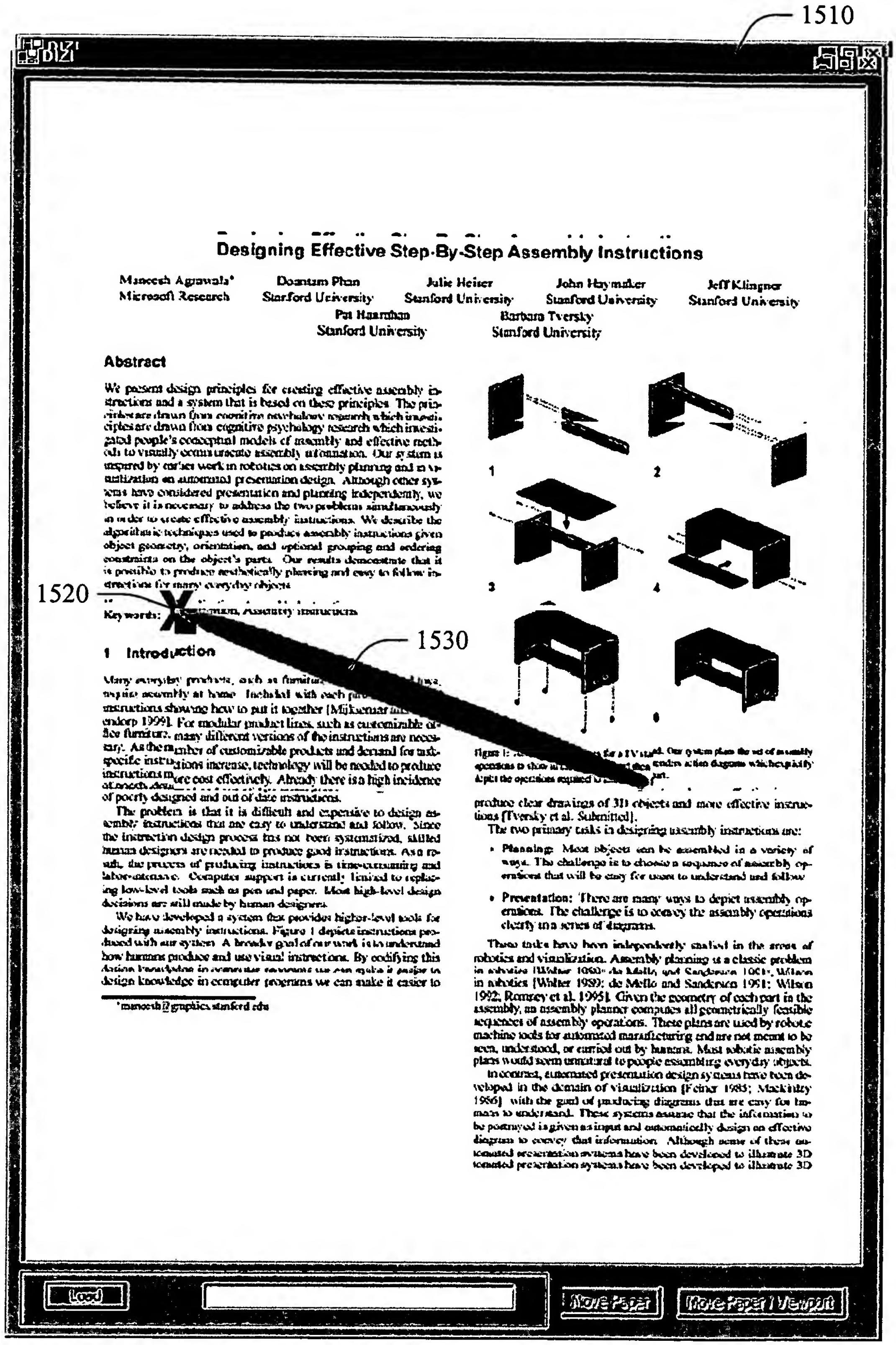
1986], with th
mans to unders
be portrayed is
diagram to co
tomated presen

FIG. 14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Designing Effective Step-By-Step Assembly Instructions
Abstract
1 Introduction
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FIG. 15


Designing Effective Step-By-Step Assembly Instructions
Abstract
ructions for many everyday objects.
eywords: Visualization, Assembly Instructions
Add more Keywords – Planning, Presentation, AI
Introduction
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1610
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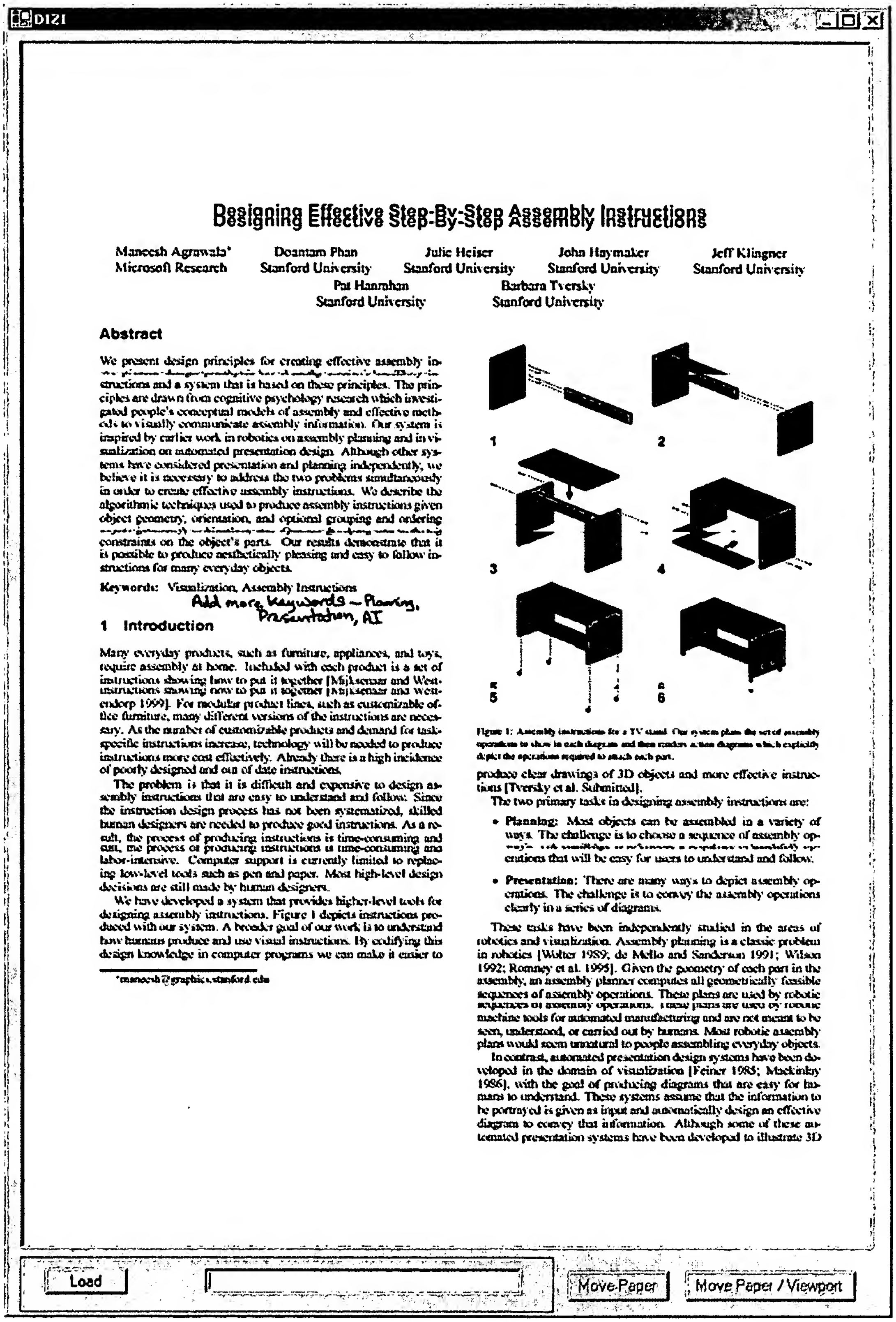
FIG. 16



Designing Effective Step-By-Step Assembly Instructions

Maneesh Agrawala* Microsoft Research
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Julie Heiser Stanford University
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Barbara Tversky Stanford University

Abstract

We present design principles for creating effective assembly instructions and a system that is based on these principles. The principles are drawn from cognitive psychology research which investigated people's conceptual models of assembly and effective methods to visually communicate assembly information. Our system is inspired by earlier work in robotics on assembly planning and in visualization on automated presentation design. Although other systems have considered presentation and planning independently, we believe it is necessary to address the two problems simultaneously in order to create effective assembly instructions. We describe the algorithmic techniques used to produce assembly instructions given object geometry, orientation, and optional grouping and ordering constraints on the object's parts. Our results demonstrate that it is possible to produce aesthetically pleasing and easy to follow instructions for many everyday objects.

Keywords: Visualization, Assembly Instructions

Add more keywords – Planning, Presentation, AI

1 Introduction

Many everyday products, such as furniture, appliances, and toys, require assembly at home. Included with each product is a set of instructions showing how to put it together [Mijksenaar and Westendorp 1999]. For modular product lines, such as customizable office furniture, many different versions of the instructions are necessary. As the number of customizable products and demand for task-specific instructions increase, technology will be needed to produce instructions more cost effectively. Already there is a high incidence of poorly designed and out of date instructions.

The problem is that it is difficult and expensive to design assembly instructions that are easy to understand and follow. Since the instruction design process has not been systematized, skilled human designers are needed to produce good instructions. As a result, the process of producing instructions is time-consuming and labor-intensive. Computer support is currently limited to replacing low-level tools such as pen and paper. Most high-level design decisions are still made by human designers.

We have developed a system that provides higher-level tools for designing assembly instructions. Figure 1 depicts instructions produced with our system. A broader goal of our work is to understand how humans produce and use visual instructions. By codifying this design knowledge in computer programs we can make it easier to

*maneesh@graphics.stanford.edu

1 2 3 4 5 6

Figure 1: Assembly instructions for a TV stand. Our system plans the set of assembly operations to show in each diagram and then renders action diagrams which explicitly depict the operations required to attach each part.

produce clear drawings of 3D objects and more effective instructions [Tversky et al. Submitted].

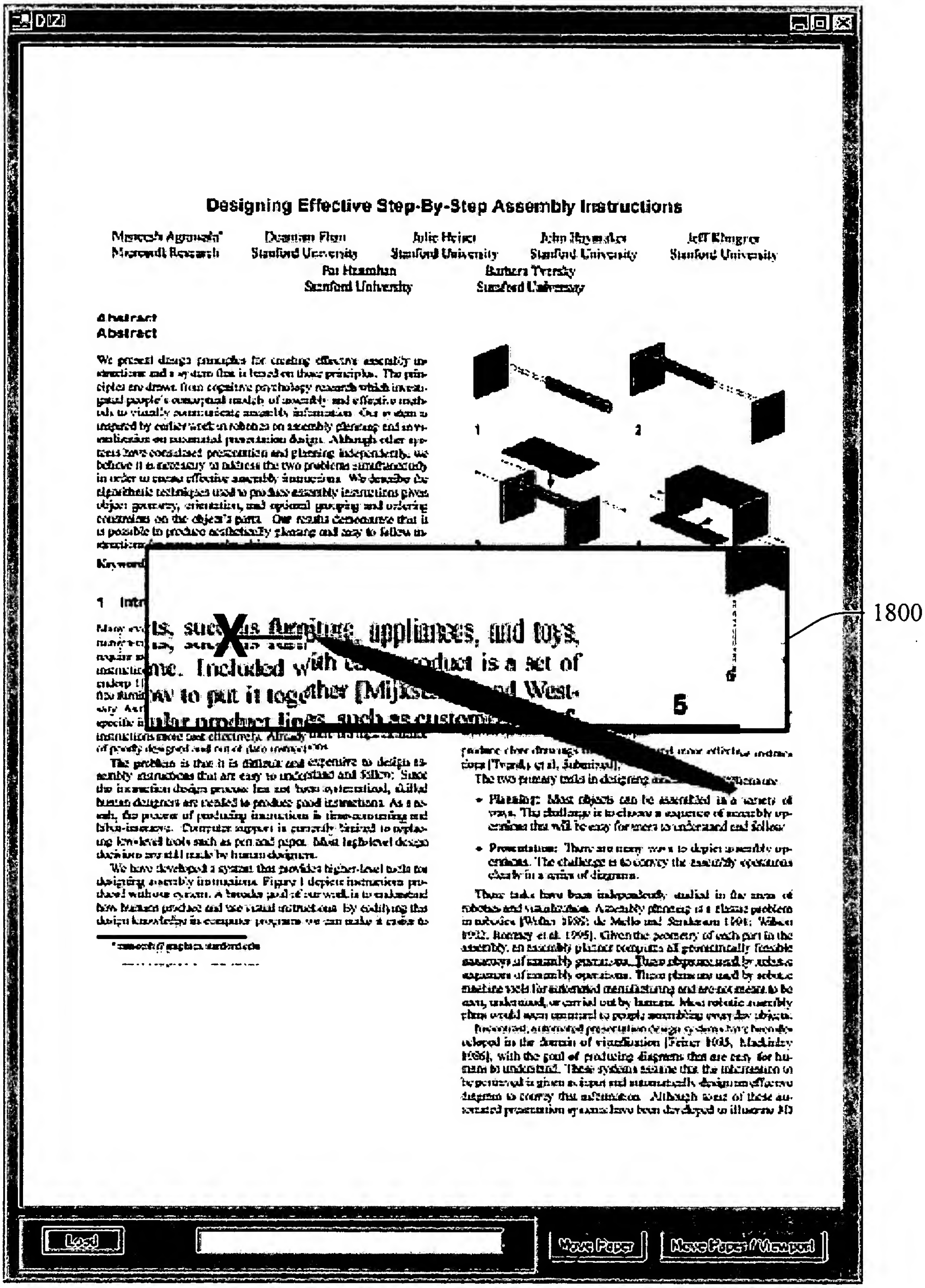
The two primary tasks in designing assembly instructions are:

- **Planning:** Most objects can be assembled in a variety of ways. The challenge is to choose a sequence of assembly operations that will be easy for users to understand and follow.
- **Presentation:** There are many ways to depict assembly operations. The challenge is to convey the assembly operations clearly in a series of diagrams.

These tasks have been independently studied in the areas of robotics and visualization. Assembly planning is a classic problem in robotics [Wolter 1989; de Mello and Sanderson 1991; Wilson 1992; Romney et al. 1995]. Given the geometry of each part in the assembly, an assembly planner computes all geometrically feasible sequences of assembly operations. These plans are used by robotic machine tools for automated manufacturing and are not meant to be seen, understood, or carried out by humans. Most robotic assembly plans would seem unnatural to people assembling everyday objects.

In contrast, automated presentation design systems have been developed in the domain of visualization [Feiner 1985; Mackinlay 1986], with the goal of producing diagrams that are easy for humans to understand. These systems assume that the information to be portrayed is given as input and automatically design an effective diagram to convey that information. Although some of these automated presentation systems have been developed to illustrate 3D

FIG. 17



Designing Effective Step-By-Step Assembly Instructions
Stanford University
Pat Hanrahan
Barbara Tversky
Abstract
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2
5
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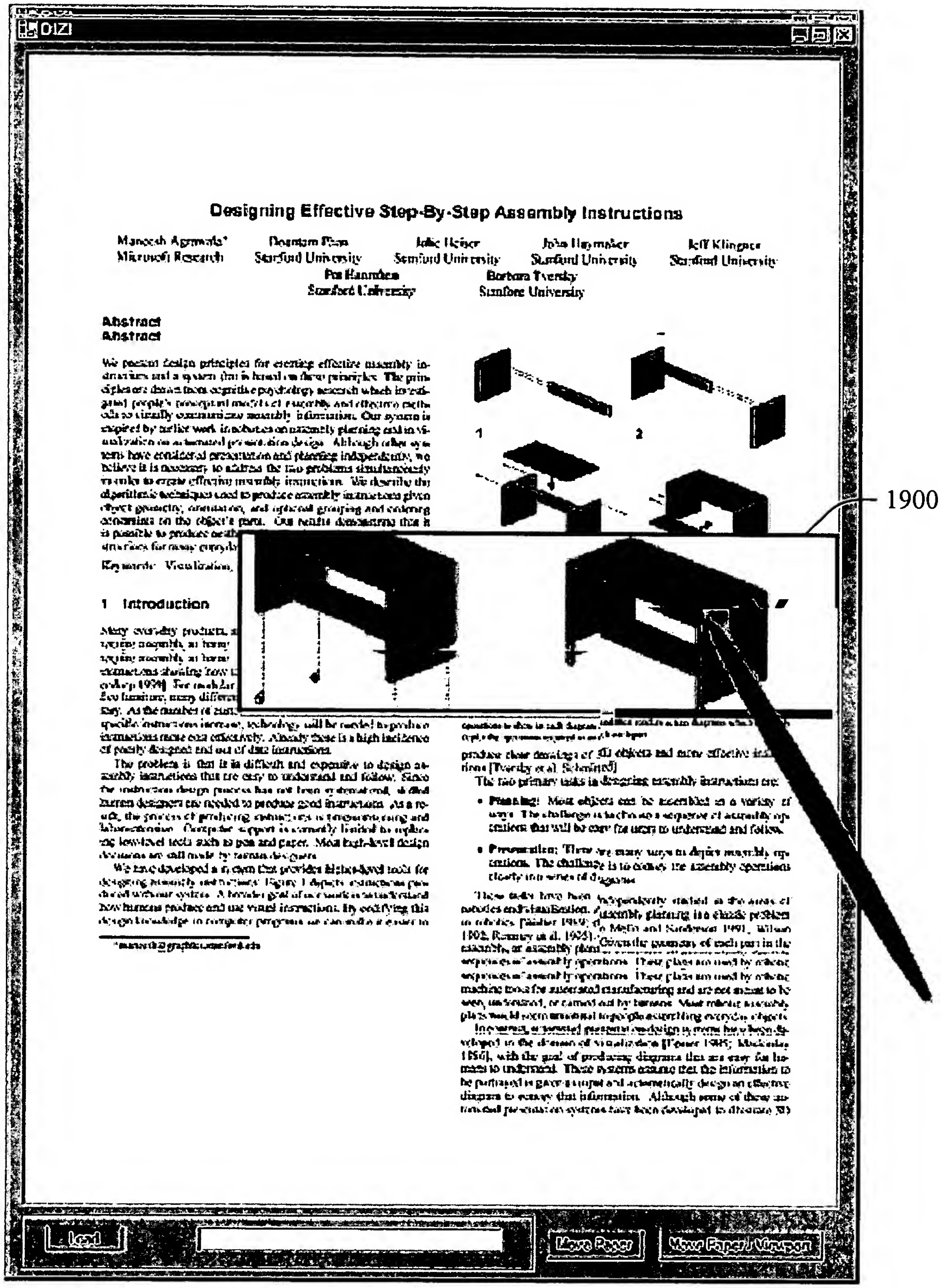
FIG. 18



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Abstract
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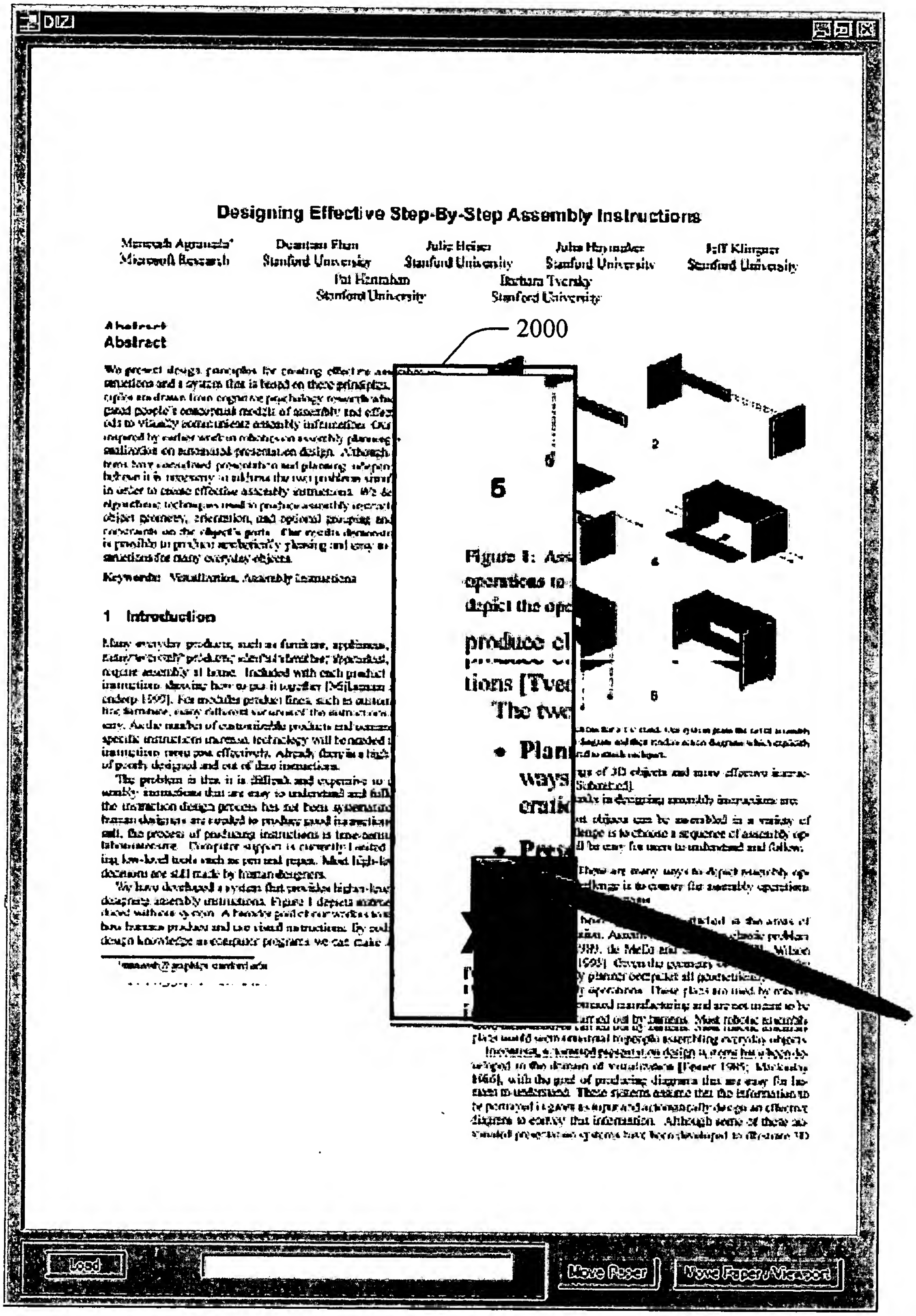
FIG. 19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Designing Effective Step-By-Step Assembly Instructions
Abstract
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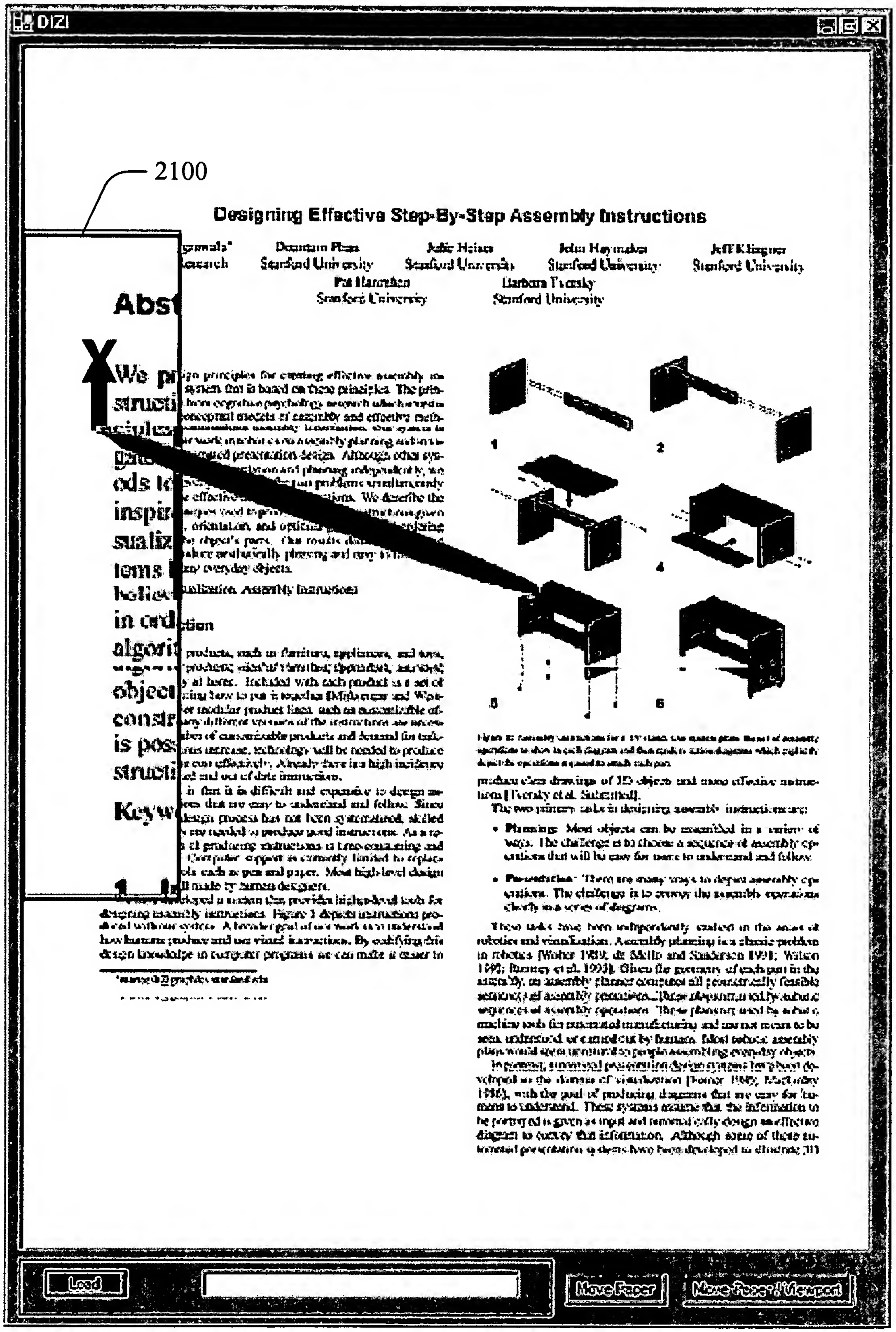
FIG. 20



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DIZI
Designing Effective Step-By-Step Assembly Instructions
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FIG. 21

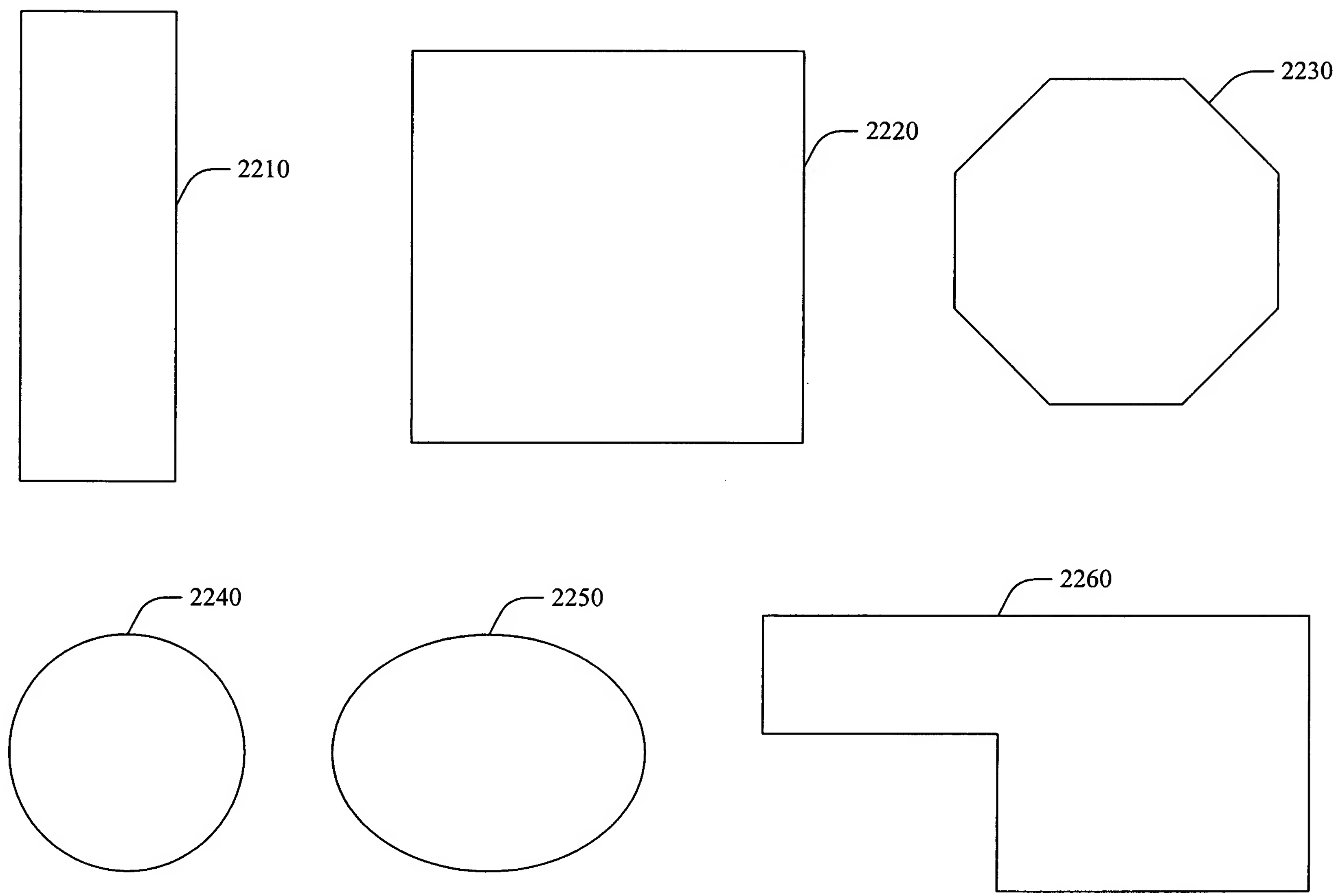

FIG. 22

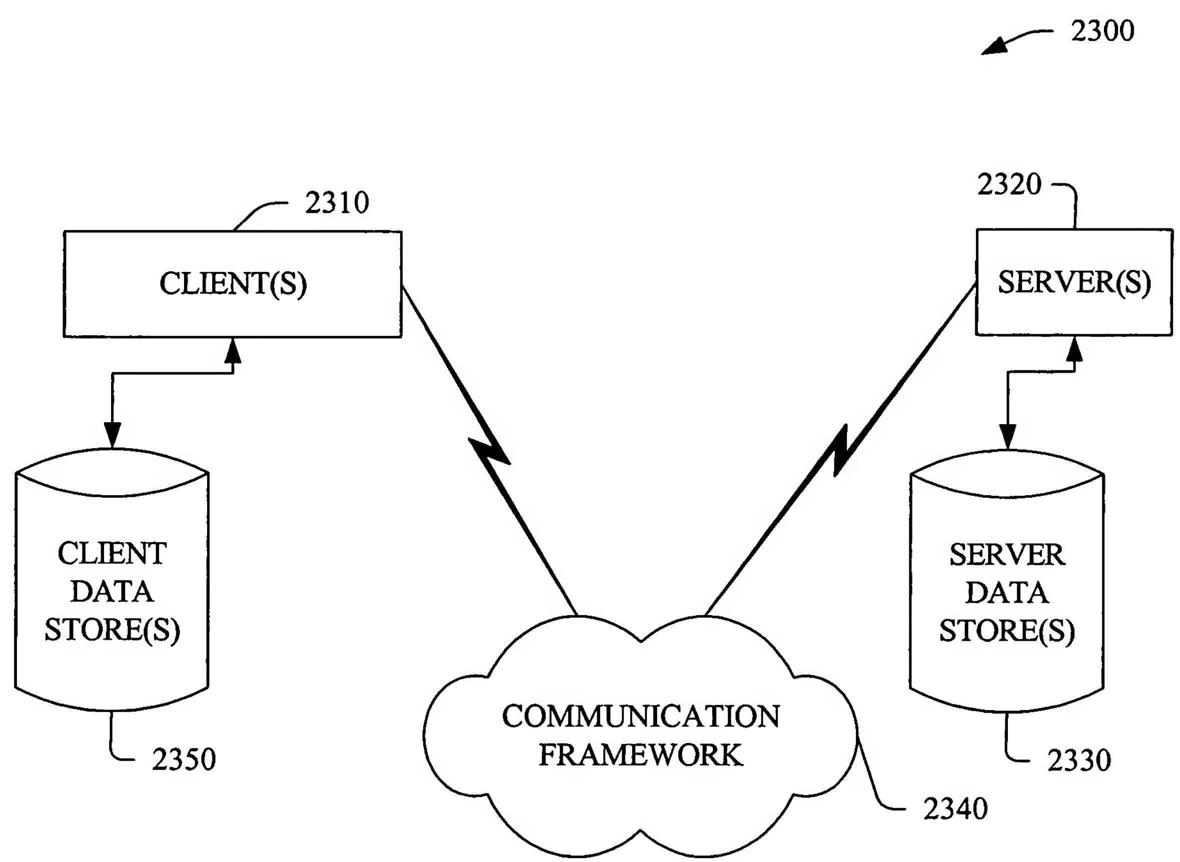
2300
2310
CLIENT(S)
2320
SERVER(S)
CLIENT
DATA
STORE(S)
SERVER
DATA
STORE(S)
COMMUNICATION
FRAMEWORK
2350
2330
2340

FIG. 23

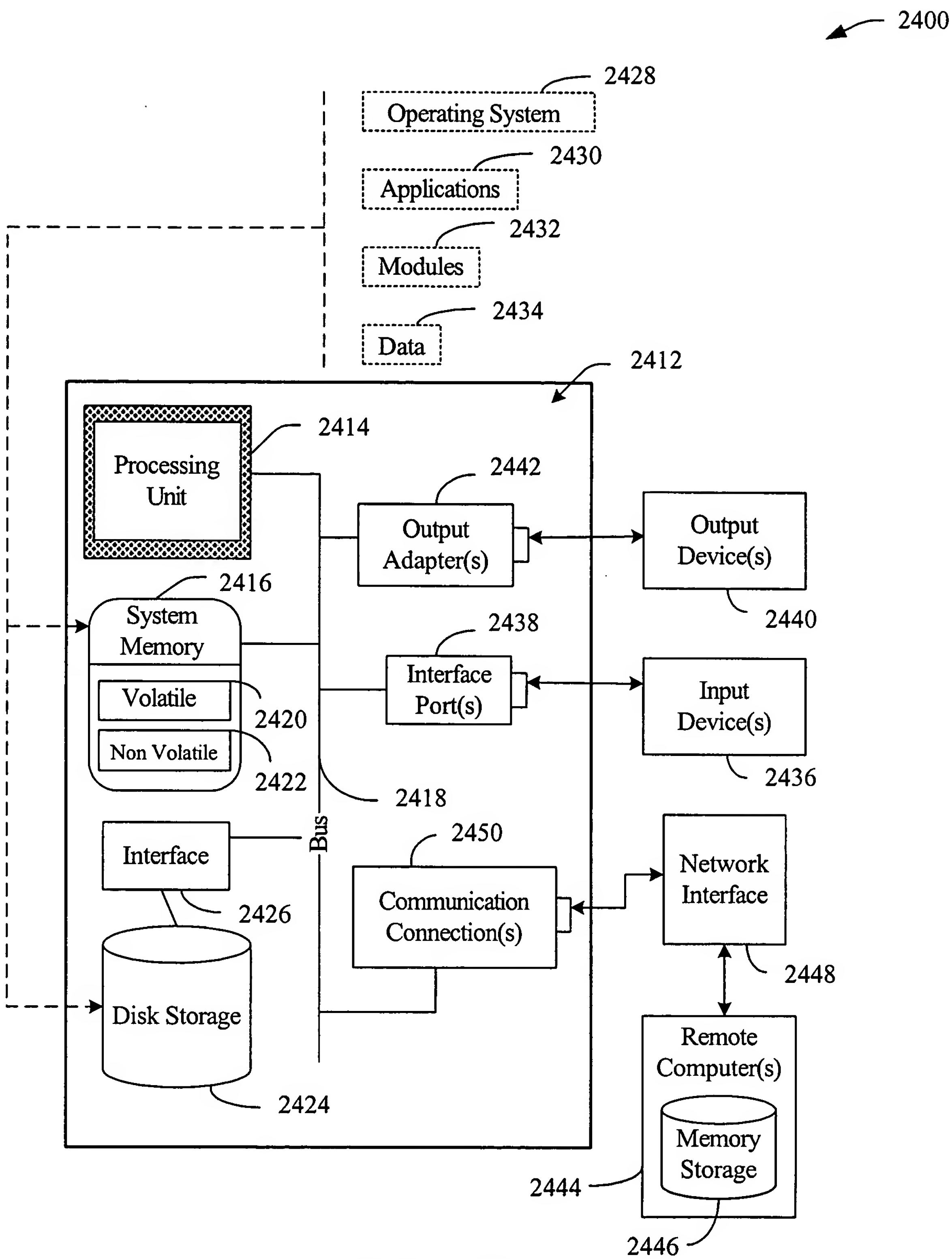
2400
2428
Operating System
2430
Applications
2432
Modules
2434
Data
2412
Processing Unit
2414
2442
Output Adapter(s)
Output Device(s)
2440
2416
System Memory
Volatile
2420
Non Volatile
2422
2438
Interface Port(s)
Input Device(s)
2436
2418
Interface
Bus
2450
Communication Connection(s)
Network Interface
2426
2448
Disk Storage
Remote Computer(s)
Memory Storage
2424
2444
2446

FIG. 24